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ABSTRACT

The experiment tested the effects of presentation word orders in a multitrial free-recall task. Three types of presentation were used: (1) randomized; (2) constant order; and (3) maintained order (maintenance of subjects order of recall on the subsequent presentation). In addition, the effects of number of recalls per presentation (1 or 3) were tested for each type of presentation. Results show the constant order group with single recalls to be superior to all other groups on mean number of words recalled. Measured organization indicated superiority for both constant order groups. The results are discussed in terms of a dual function of presentation hypothesis with emphasis on the distinction between primary and secondary organization. (Author)

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THE EFFECTS OF PRESENTATION ORDER IN MULTITRIAL FREE RECALL

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The Effects of Presentation Order in Multitrial Free Recall

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Presented with a word list of greater than span length, Ss will typically recall a number of words on their first attempt and increase the number of words in their recalls after subsequent presentations. A phenomenon which accompanies this increase in number of words in recall is the increase in the similarity between the orders in which Ss recall words in succeeding trials. The "organization" of the randomly presented words into orderly recalls has been studied extensively by Tulving (1962, 1964, 1968) under the rubric Subjective Organization.

Using alternating presentations and recalls over a total of 22 trials, Tulving (1964) has shown that the increase in measured subjective organization is highly correlated with the increase in the CC count (number of words appearing in both the recall before and the recall after a list presentation). He has suggested that this correlation "indicated the dependence of increments in recall on the strengthening of specific interitem associations (1968, p. 22)."

In research concerning the effects of presentation and recall trials on performance, Tulving (1967) found that Ss required to give multiple recalls after each presentation of the list suffered no disadvantage when number of words recalled by them was compared to that of

Ss who experienced alternating presentation and recall trials for an equivalent period of time. While the degree of organization present on the recalls was not given, Tulving did report comparable CC scores for the two groups. This multiple recall paradigm was replicated and expanded by Donaldson (1970) who reported no main effect differences in number of words recalled by Ss required to give 1, 3, 5, or 7 recalls per presentation of a randomly presented 40-word list (although there were interaction effects with trials). Within the 50 trials, Ss in Donaldson's 7 consecutive recall condition saw only 7 presentations of the list while giving 43 recalls. Ss in the single recall condition saw the list 25 times and gave 25 recalls. The results indicated no reliable differences in number of words recalled or in degree of organization among the groups at the end of 50 trials.

In studying the effects of presentation and recall trials on organization, Rosner (1970) reported that there was similarity of effect for both types of trials on the "formation" of organizational units, but that recalls produced more "consolidation" of organizational units than did presentation trials. The major difference reported by Rosner was in greater stereotypy in the Ss receiving more recalls.

Although slightly at odds with Rosner's interpretation, it may be possible to account for the data reported by hypothesizing presentation trials as opportunities for "formation" of organizational units only, while recalls are opportunities for "stabilization" or "consolidation" of those units. Thus, the formal difference in type of trial (e.g., presentation or recall) also represents a functional difference (e.g., formation or stabilization). With Rosner's paradigm of presentations

(P) and recalls (R), we have a situation where PPRRRRRR = 2 formation and 6 stabilization trials; PPPRPRRR = 4 formation and 4 stabilization trials; PPPPPPRR = 6 formation and 2 stabilization trials. All conditions yield a functional sum of 8 and result in no differences in organization (computed as bidirectional ITR), and no differences in number of words recalled. Donaldson's data can be similarly handled: PRPRPR...$P_{25}R_{25}$ = 25 formation and 25 stabilization trials; PRRRRRRR...$P_{7}R_{43}$ = 7 formation and 43 stabilization trials. Since, once again, the functional sums for both groups are equal, we can predict equal organization and equal recall on the last trial. To test this hypothesis it will be necessary to change the functional balance between the groups and look for a change in performance.

It seems reasonable to assume that if one monitors the S's organization, as evidenced by the word order used on his last recall, and maintains that order for the words in the next presentation, one would be allowing the S to stabilize his organization to a similar degree as if he were allowed to recall it again. By also presenting the words not recalled, one would be giving S an opportunity to form new organizational units. Each presentation (beyond the first) would therefore be both a stabilization and a formation trial. A paradigm of PRPRPRPR = 4 formation and 7 stabilization trials, PRRRPRRR = 2 formation and 7 stabilization trials yields functional sums which are different (e.g., 11 and 9) and we could expect the performance measures to differ accordingly.

Constancy of word order on presentation, however, brings with it another set of considerations. Tulving (1968) distinguishes between two

types of organization: primary (list defined, e.g., primacy and recency effects); and secondary (S defined, e.g., associative and/or categorical clustering). In his experiments, Tulving orders list presentations so that words do not occur in the same serial position or occur contiguously with any other word more than once. In this way, any similarity of word order between recalls is assured of being the S's secondary organization. It seems reasonable to assume, however, that given a list in constant order Ss might use: a) only secondary, b) only primary, or c) a combination of both to achieve their recall. This question has not, however, received experimental attention. Tulving mentions (in a different context, 1968) Waugh's work (1961) which indicates no differences in number of words recalled between serially presented and randomly presented lists in a multitrial free-recall task. These results have been challenged by Jung and Skeebo (1967), and Lachman and Laughery (1968), while being supported by Stimmel and Stimmel (1967). The heterogeneity of experimental conditions among these studies (Waugh: college students, within subjects design; Jung and Skeebo: seventh- and eighth-graders, between subjects design; Stimmel and Stimmel: nonsense syllables instead of words) makes direct comparison hazardous and, due to the contradictory results, inconclusive.

The present experiment will, therefore, attempt to affect the use which Ss can make of the presentation trials by manipulating the order of presentations. Three types of presentation and two levels of exposure to the word list will be used:

Random presentation will approximate the method used by Tulving, Donaldson, and Rosner. Ss receiving a single recall per presentation

and Ss receiving three recalls will have equal functional sums at the end of an equal number of trials and can be expected to reflect equivalent performance levels.

Maintained presentation will give Ss their own word order (as determined by their last recall) and thereby allow for an approximation of a "stabilization" trial while, at the same time, presenting words not on the prior recall, in a newly randomized order at the end of the list, to allow for a "formation" trial. This "dual function" trial should result in a higher functional sum for the group which receives the most presentations and should also result in higher performance levels for that group.

Constant presentation will allow a control for the effects of contiguous presentations of words across trials. If the superiority of the maintained group is due to the fact that some words are presented in a constant order, then the constant groups should show even higher performance levels than the maintained since all words will be presented in a constant order. In terms of the formation-stabilization hypothesis, each presentation will have a "dual function" to the extent that Ss use the presentation order as a basis for their organization. With no conclusive experimental evidence for how Ss will use primary organization, no prediction of performance level can be made.

Method

Subjects. Ninety-six introductory psychology students of the University of Pittsburgh, fulfilling a course requirement, served as subjects.

Males and females were equally represented and all were native English speakers.

Apparatus. Two lists of 40 words each were chosen from the Thorndike-Lorge (1944) AA listings. Words were chosen which are nouns of one or two syllables and five or six letters. Lists were presented, under computer control, on a cathode ray tube.[1] Recalls were simultaneously written and spoken by S, with E feeding the spoken response into the computer by means of a touch sensitive screen located in the same room, but out of sight of S, who sat in isolation.[2] All presentations and recalls were recorded by the PDP 7 and 9 computers and also tape recorded.

Design. The first presentation to each subject consisted of a randomly generated word order. The second presentation was a different random order (random groups), a repetition of the previous order (constant groups), or an ordering based on the words in the individual S's recall (maintained groups). Ss in the maintained groups received the next list presentation with the words which they had recalled on the immediately preceding trial at the beginning of the presentation, and in the same order as they had used in recalling. All words not recalled were presented in a newly randomized order following the "maintained"

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[1]The author wishes to gratefully acknowledge the immeasurable contribution to the conduct of this research made by the staff of the Computer Facility of the Learning Research and Development Center. Special thanks to Bill Schmiedlin and Maurice Jager for their excellent programming.

[2]The touch sensitive screen is a projection screen containing embedded wires which, when touched, transmit the coordinates of the area touched to the computer (Fitzhugh & Katsuki, 1970).

words. Words repeated during a recall were recorded but the repetition was ignored in ordering the next presentation. Intrusions were ignored for all groups. Each of the three experimental groups was further divided into subgroups required to give either one or three recalls after each presentation. The design was, therefore, 2x3 factorial, with lists and sex counterbalanced within each cell. Four Ss served in each condition (type of presentation, number of recalls, list and sex).

Procedure. Ss arriving at the laboratory were randomly assigned a condition from a 3x2x2 (presentation x recall x list) matrix with the restriction that the number of Ss in a cell would not exceed the number in any other by more than one at any given time. Different matrices were used for males and females to ensure an equal distribution with independent assignment. Ss received instructions suitable to the number of recalls they would be required to make, but were told nothing about the presentation order. Words were presented at a 2-second rate and recall periods were 80 seconds, thereby ensuring an equal "total time" for all Ss, regardless of number of recalls. A total of 38 80-second periods was given each S with single recall groups receiving 19 presentations and 19 recalls; multiple recall groups received 10 presentations and 28 recalls.

Recalls were simultaneously spoken aloud and written on a pad of paper with instructions to write only as much of the word as there was time for, and to begin each recall on a clean sheet. Ss in multiple recall conditions were required to turn the page and begin the next recall at the signal of a flash from the screen and a brief tone.

Results

The results of this experiment will be presented as number of words recalled, number of CCs, and a measure of organization called ratio ITR (Donaldson, 1970). Number of words recalled is the familiar measure. Tulving (1964) defines CCs as that subset of the number of words recalled on trial n which were also recalled on trial n - 1 and has shown that the CC count is highly correlated with his organizational measure, SO.

The ratio ITR (intertrial repetition) is computed as $\frac{O - E}{M - E}$ where O = observed ITR, the number of times words recalled on both recall n - 1 and n are recalled contiguously on each recall, regardless of order within the pairing (bidirectional); E = expected ITR, the chance value of such occurrences (Bousfield & Bousfield, 1966); M = maximum ITR, the greatest number of such pairings possible given the number of CCs. Ratio ITR is used to gain a measure of the degree of organization present in a recall which is independent of the number of words recalled.

Figure 1 presents data on the number of words recalled for all groups in all recall trials. The familiar learning curve is in evidence for all groups and the curve for the constant-one group (constant order of presentation with one recall per presentation) lies above all others. The joined lines for successive recalls illustrate the characteristic loss of one or two words from the first to the second recall. Following Tulving and Donaldson, we will analyze only those recalls which: a) immediately followed a presentation, and b) represent the same total time in the experimental situation (e.g., same trial number for all groups).

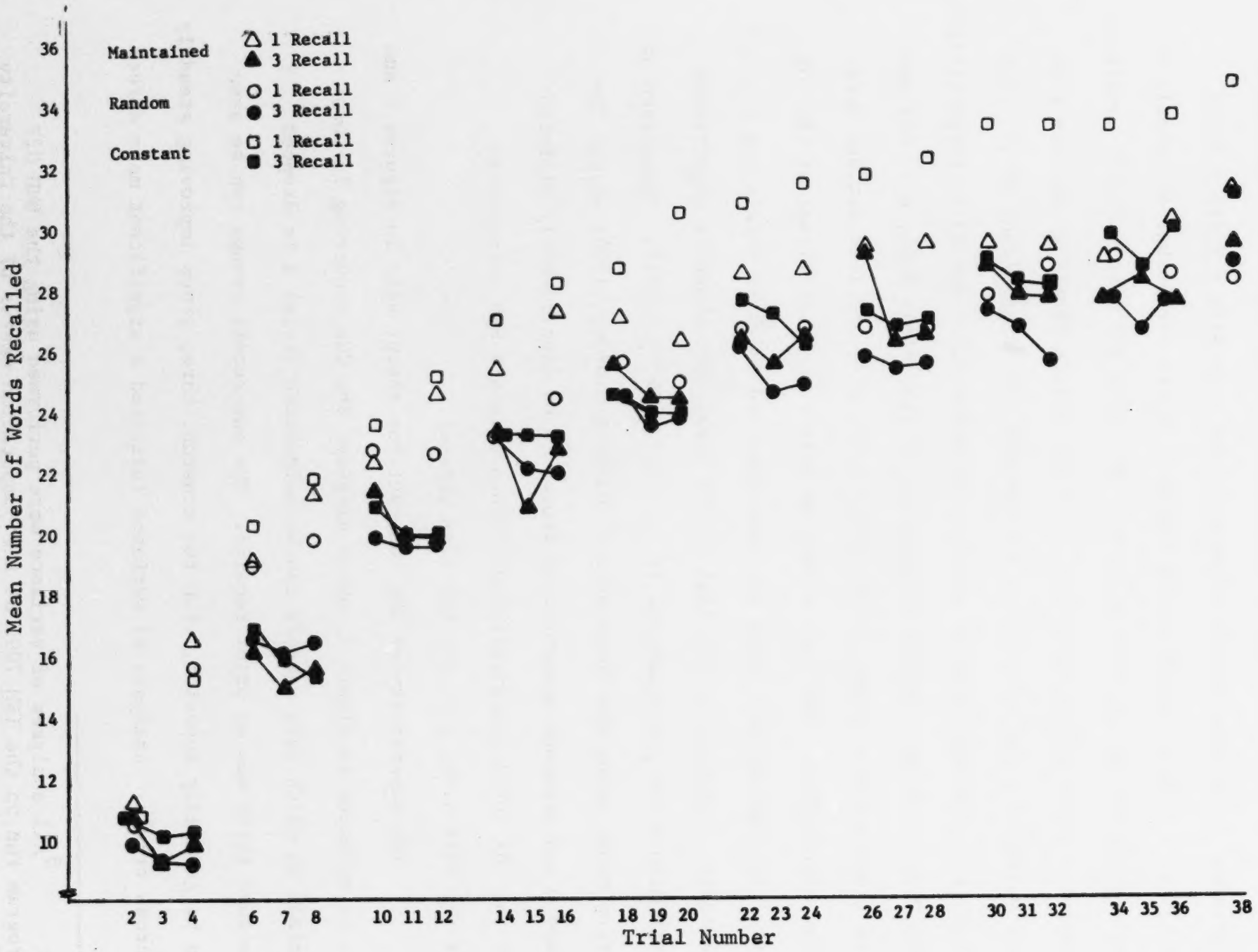

Figure 1

Mean Number of Words Recalled for All Recall Trials

With these restrictions, the recalls in trials 2, 6, 10, 14, 18, 22, 26, 30, 34 and 38 qualify and are plotted in Figure 2. Analysis of variance[3] in a 3x2x2x2x4x10 (Presentations x Recalls x Lists x Sex x Subjects x Trials) model showed the main effect for number of recalls to be significant ($F(1, 72) = 5.08$, $p < .05$) with the single recall condition superior (mean number of words: 25.5 for single recall groups and 23.6 for multiple); the main effect for sex was also significant ($F(1, 72) = 4.39$, $p < .05$) with females superior to males (25.4 and 23.7, respectively). The Presentations x Trials interaction ($F(18, 648) = 1.94$, $p < .05$) and the Lists x Sex x Trials ($F(9, 648) = 1.94$, $p < .05$) interactions were also significant. The main effect of trials was significant at the .01 level in this and all other analyses reported in which trials was a variable. Analysis of the last recall trial only showed a significant main effect for presentations ($F(2, 72) = 5.28$, $p < .01$). Comparison of group means using the Tukey method (Glass & Stanley, 1970) showed the random and constant presentation groups to be significantly different at the .01 level. A significant Presentations x Sex interaction ($F(2, 72) = 4.32$, $p < .05$) was also present.

The superiority of the constant-one group, seen in Figures 1 and 2, is enhanced in Figure 3, which displays the CCs occurring in those trials in which this measure can be calculated (trial 2 is dropped because there was no prior recall). The one-recall groups can be seen to be generally superior, with the constant-three group improving steadily across trials. Analysis of variance indicated a significant main effect

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[3]All analyses of variance were performed using the BMD 02V program run on the IBM 7090 at the Computation Center of the University of Pittsburgh.

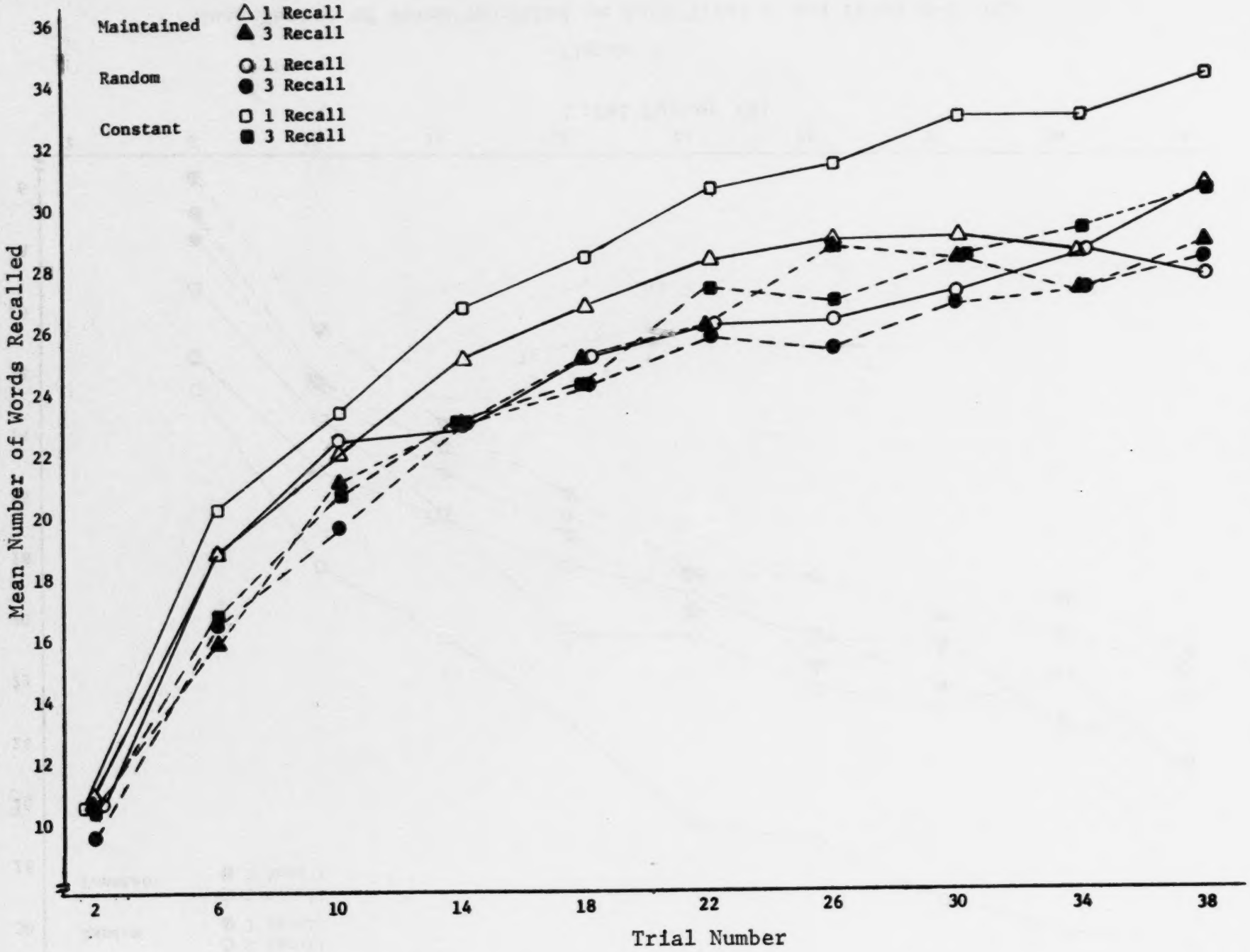

Figure 2

Mean Number of Words Recalled for Trials in Which All Ss Are Recalling Immediately Following a Presentation

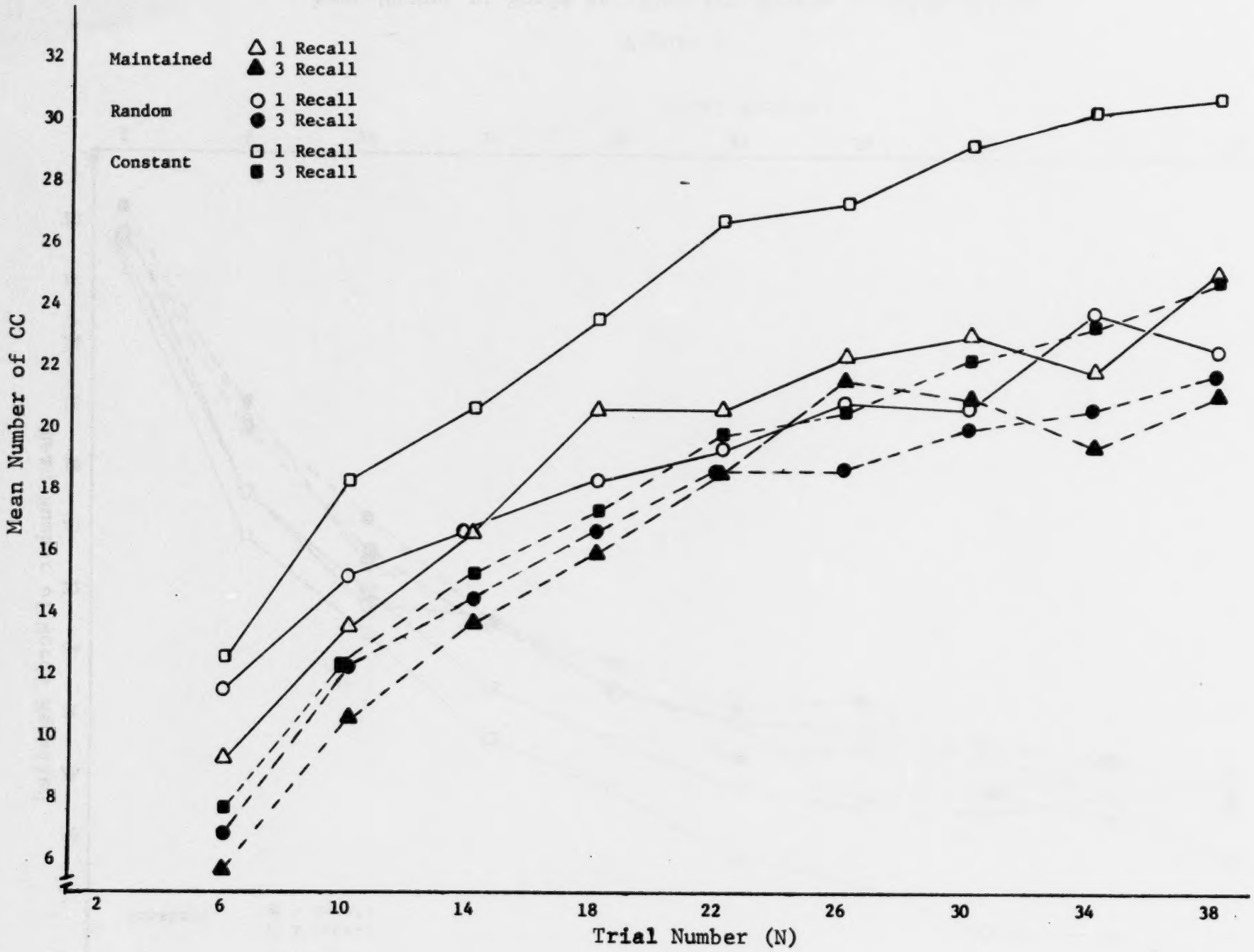

Figure 3

Mean Number of Words Recalled on Both Trial N and Trial N-1 (CC)

for presentations ($F(2, 72) = 4.66$, $p < .05$) with group mean CCs: maintained, 17.7; random, 17.5; and constant, 21.2. The Tukey comparison of means failed to reach significance, however. The main effect for recalls ($F(1, 72) = 12.04$, $p < .01$) was also significant with means of 20.6 and 16.9 for single and multiple recall groups, respectively. The interactions Lists x Sex ($F(1, 72) = 4.63$, $p < .05$) and Presentations x Trials ($F(16, 576) = 2.88$, $p < .01$) were also significant.

The measure of organization used was the recall-to-recall ratio ITR; the relevant data points are plotted in Figure 4. The data points represent the ratio ITR computed between the recall on the trial number plotted and the immediately preceding recall, which is not plotted. Analysis of variance on all points (3x2x2x2x4x9) indicated a highly significant main effect for presentations ($F(2, 72) = 12.92$, $p < .01$), and the Tukey comparison indicated both the constant and the maintained groups to be significantly superior to the random group. A significant Presentations x Trials interaction ($F(16, 576) = 1.99$, $p < .05$) was also present.

Searching for the origin of the organization shown in the recall-to-recall ITR (RR ITR), Figure 5 plots the presentation-to-recall ratio ITR (PR ITR) which, rather than counting the recall before and after a presentation, looks at the presentation and its immediately following recall. Any commonality of word order between the two may be considered organization which the subject has taken from the presentation. Extremely low levels of this measure are seen for the random presentation groups, while the constant-one, maintained-one, and maintained-three are much

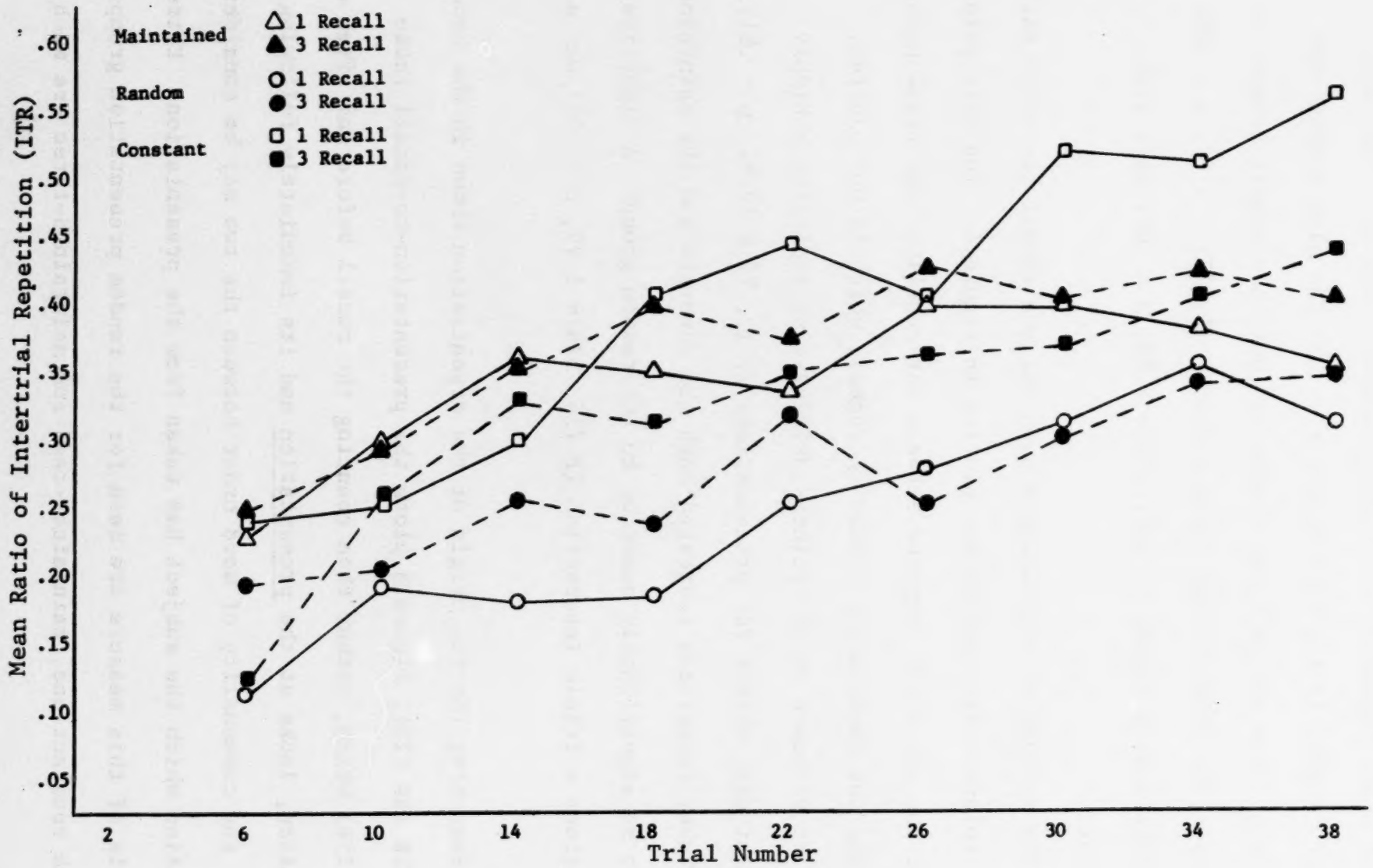

Figure 4

Mean Ratio ITR Computed Recall-to-Recall (RR ITR)

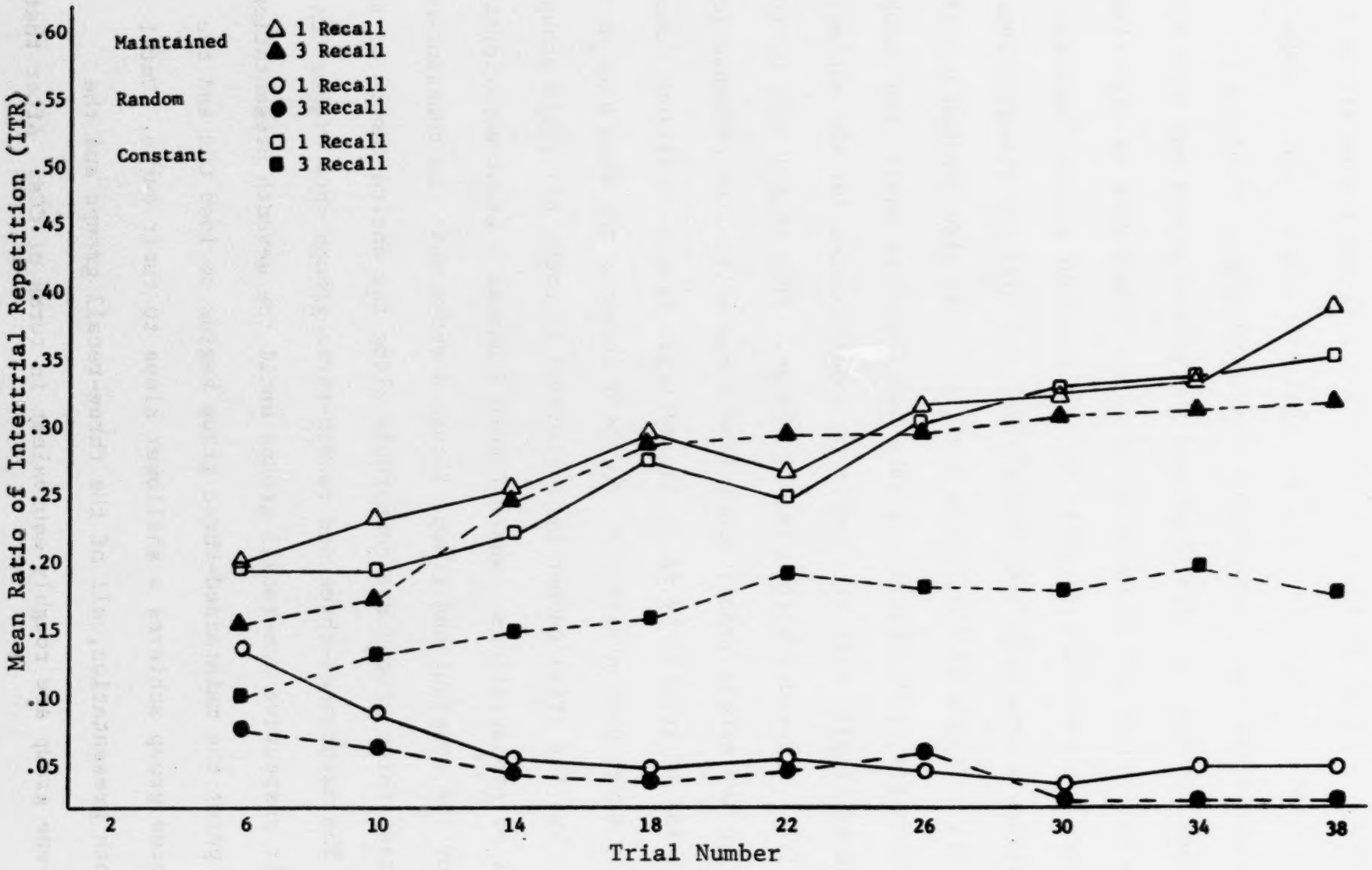

Figure 5

Mean Ratio ITR Computed Presentation-to-Recall (PR ITR)

higher; the constant-three group is seen as being intermediate. Analysis of variance indicated a highly significant main effect for presentations ($F(2, 72)= 65.23$, $p < .01$) and recalls ($F(1, 72)= 8.84$, $p < .01$) with Presentations x Lists ($F(2, 72)= 3.67$, $p < .05$) and Presentations x Recalls x Lists ($F(2, 72)= 5.34$, $p < .01$) also significant. Comparison of the group means for presentations indicated highly significant differences between the maintained and the random groups and also between the constant and random presentation groups. There were no significant differences between the maintained and the constant groups, however. Presentations x Trials ($F(16, 576)= 7.68$, $p < .01$) and Presentations x Lists x Sex x Trials ($F(16, 576)= 1.92$, $p < .05$) also reached significance.

Thus far, all comparisons have been based on equal time (number of 80-second trials) with the number of opportunities for the subject to see the list confounded across recall groups. (The recall made on trial 10 by Ss in the single recall conditions comes after five presentations, whereas trial 10 recalls by Ss in the multiple recall conditions comes after only three presentations.) Figure 6 presents the same data as in Figure 3, but the trial number is confounded in order to equate groups on number of presentations. Where Figure 3 showed a great superiority in CCs for the constant-one group, Figure 6 shows that the constant-one and constant-three groups are comparable along the entire length of their curves. The maintained-three and random-three groups show higher CCs than their respective one-recall groups until the seventh presentation, at which point the maintained-three group begins to lose CCs and the random-three group achieves a shallower slope to their curve. Until the seventh presentation, all of the three-recall groups and the constant-one group are roughly equivalent in terms of CCs. After that

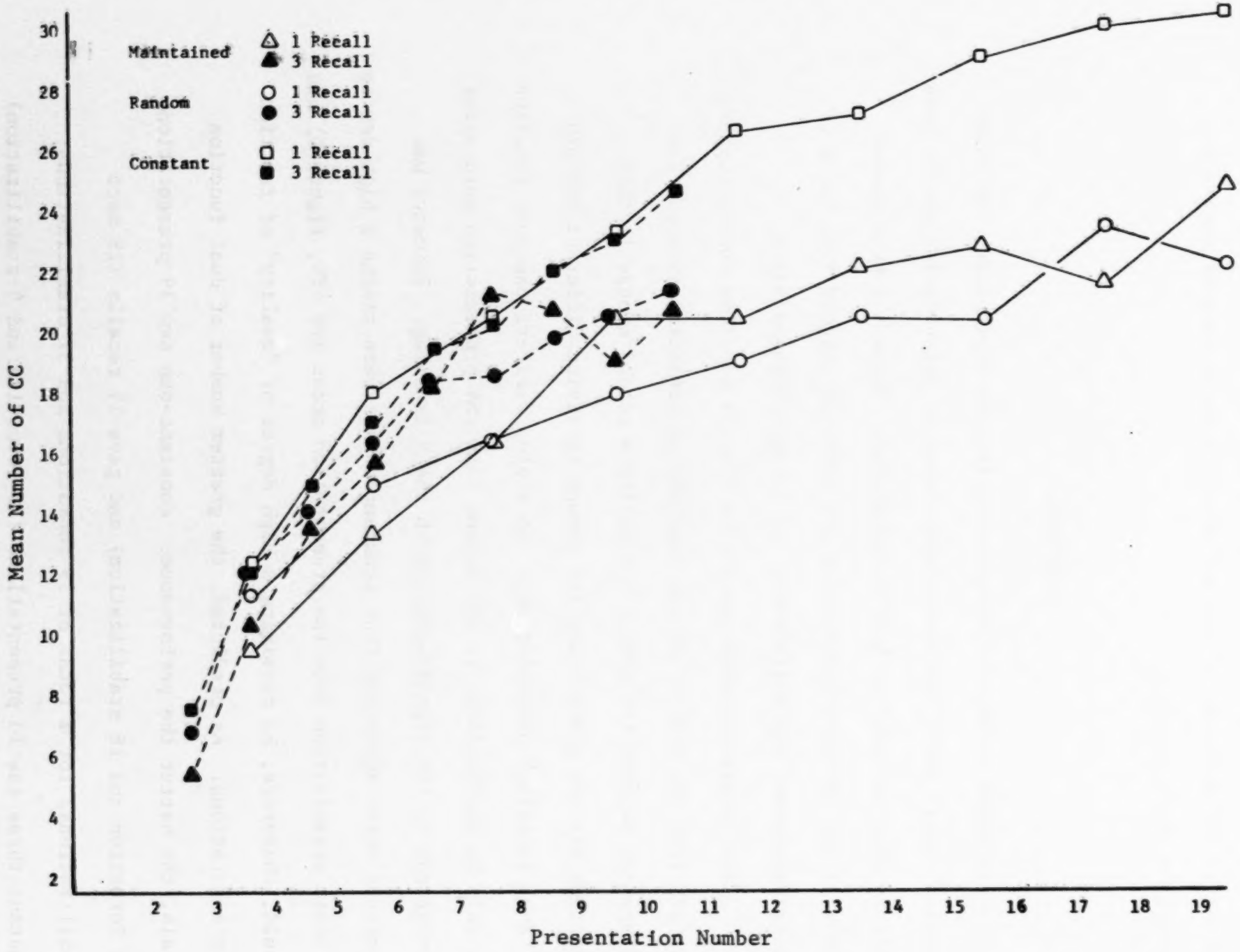

Figure 6

Mean Number of CCs Plotted as a Function of Number of Presentations

point, the constant-one group continues to improve while the others slump. The curves for maintained-one and random-one fall below their respective three-recall groups and are seen to be roughly equivalent throughout their length.

Discussion

In terms of the formation-stabilization hypothesis, the "dual function" trial which the maintained method of presentation was to have achieved does not seem to have materialized. While the performance levels of the maintained-one group are generally higher than those of maintained-three, the differences are disappointingly small.

The formation-stabilization hypothesis received strong support, however, from the results of the constant presentation groups. The differences between the single and multiple recall groups in this condition fit the predictions for groups receiving different numbers of "dual function" presentations. As stated earlier, the dual function can only be accomplished to the extent that the presentation word order corresponds to the organization which the S is using. Evidence was presented which indicated that constant-one Ss were taking a high degree of their organization from the presentation order (PR ITR, Figure 5) and should, therefore, be receiving a high degree of "duality" of function on presentations. As predicted, the greater number of dual function trials, the better the performance: constant-one saw 19 presentations (19 formation and 18 stabilization) and gave 19 recalls (19 more stabilizations) for a total of 19 formations and 37 stabilizations; constant-three saw 10 presentations (10 formation and 9 stabilization)

and gave 28 recalls (28 more stabilizations) for a total of 10 formations and 37 stabilizations. This difference in functional sums is reflected in the large difference in performance as reported earlier.

A tentative explanation of the failure of the maintained-one group to show the expected facilitation involves an assumption which cannot be supported from the data presented, but must await a follow-up study. If a dual function trial is to be achieved, the stabilization portion of the trial must contain S's organization. It was informally observed, however, that Ss were making use of the "recency effect" by quickly saying the last few words from the presentation list as the first words on their recalls. These words would then appear as the first words of the next presentation. If the "recency" words were not really part of S's organization but were, instead, merely in an "echo box" (Waugh & Norman, 1965), the maintenance of these words in the initial position on the next presentation would not constitute a stabilization at all.

Further complicating the picture is the fact that Ss who omitted a cluster from a recall found the words of that cluster randomized on the next presentation. While this corresponds to the situation faced by Ss in the random presentation condition, an important difference is that the "unrecalled" words in the maintained condition were placed at the end of the presentation list and therefore had a higher probability of appearing in a near-terminal position. A formerly clustered word picked up in the recency effect and recalled with other words (not from the former cluster) surely could not exercise a stabilizing effect on the original cluster. An experiment is currently being planned which attempts

to control the disruptive influence of the recency effect by presenting the maintained words at the end of the presentation.[4]

The discussion, thus far, has centered on the failure of the maintained group, due to the presumed failure of the stabilization function of the presentation trial. Looking now at the formation function, we may hypothesize a cause for the constant-one group's superior performance. Ss presented with words in a constantly changing order must organize those words on the basis of some perceived similarity (if they are to organize the list at all). This is, by definition, secondary organization. We can see that, with the exception of the changing recency words, Ss in the random and maintained conditions have no alternative types of organization. Ss in the constant groups, however, have the primary organization of the entire list which they may incorporate into their organization. (The high PR ITR scores for the constant-one group attests to the fact that they do use this primary organization.) Since the task is free recall, there is no compulsion for Ss to use only primary organization (as there is in serial learning).

It is interesting to note that the degree of organization which the Ss "take from the list" is roughly equivalent for the two maintained groups and the constant-one. The maintained groups, however, are receiving only their own secondary organization repeated back to them (possibly mixed

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[4]Subsequent to completion of this paper a prepublication copy of a paper by Murdock, Penney, and Aamiry (1970) became available which reports such an experiment. Their data indicate no difference in number of words recalled for Ss receiving maintained words at the beginning or end of the following presentation. Since these authors have not addressed themselves to the question of organization, and have not reported their data in a manner which is useful to the question raised here, their results have not been incorporated into the discussion.

with recency words, as discussed above). Ss in the constant-one group, however, are taking primary organization and, as seen in Figure 4, reaching a much higher level of organization. This higher degree of organization may be explained as the addition of primary organization, taken from the list, to their secondary organization; a possibility not available to the maintained and random presentation groups at all, and withheld from the constant-three group by the fact that they receive fewer opportunities to see the list organization.

In discussing the formation-stabilization hypothesis in conjunction with the constant word order groups, a difference of sums (number of formation + number of stabilization trials) between the constant-one and the constant-three (56 - 47 = 9) was mentioned. This difference was equal to the difference of sums found between the constant-three and random-three (47 - 38 = 9). Despite the similarity of these comparisons, the effects on performance levels did not follow the expected pattern. Presented as 56>47>38, one would expect a similar distribution of recall and organizational scores. The distribution, however, looks more like: constant-one > constant-three = random-three. The interaction between the two hypotheses presented in this paper (dual function of presentations x presence of primary as well as secondary organization) will require a program of research to explicate. It is believed that enough data have been presented in support of these hypotheses to indicate the value of undertaking such a program.

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